MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

Vol. 55, No. 5
W. B. No. 927

MAY, 1927

CLOSED July 2, 1927
ISSUED July 30, 1927

THE NORTHEAST TRADE WINDS OF THE NORTH PACIFIC

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CHAPTER I

GENERAL RELATIONS OF THE TRADE WINDS TO PRESSURE DISTRIBUTION

Since the relative pressure of the atmosphere determines the force and direction of the prevailing winds, it is obvious that the first step toward a proper understanding of the wind systems of the globe is an examination of the general pressure distribution.

Broadly speaking, the chief features of world-pressure distribution are: (1) An equatorial belt or zone of diminished pressure, (2) a belt or zone of high pressure around the world about 30° both north and south of the Equator, and (3) a second belt of low pressure about north latitude 60° and a similar belt in the Southern Hemisphere in approximately the same latitude.

The belts of high pressure about 30° from the Equator are not continuous around the world but form a series of the well-known semipermanent anticyclones, each with its appropriate wind circulation. Similarly the belts of low pressure about 60° from the Equator are not continuous but rather a disconnected series of cyclonic wind systems which reach their greatest development in winter and over the oceans rather than the continents. The best known of these are found in the Northern Hemisphere along the Aleutian Islands in the Northeast Pacific and in the vicinity of Iceland in the Northeastern Atlantic. These two well-known semipermanent cyclcones are known as the Aleutian cyclone or LOW and the Iceland cyclone or LOW, respectively.

The most prominent semipermanent anticyclones in the Northern Hemisphere are the great Siberian anticyclone of winter, and winter only, and the two oceanic anticyclones, the Azores in the Atlantic and the North Pacific in the ocean of that name. The oceanic anticyclones are best developed in summer.

The wind circulation in these anticyclones is spirally outward from the center in a clockwise direction; that of the cyclone is exactly the opposite.

Both the cyclones and anticyclones above mentioned must not be confused with the traveling cyclones and anticyclones of the daily weather map. The latter preserve their form and travel in a definite direction over the earth's surface for a time. The former, on the other hand, must not be thought of as having a distinct entity which is continually preserved. Rather they should be thought of as representing the average monthly pressure distribution in their respective areas, and this monthly average is the result of many diverse pressure distributions. It is important that this truth be brought home to writers on pressure distribution and its influence upon the weather.

Figures 1 and 2 have been prepared to show the average pressure distribution and the prevailing winds in the Northern Hemisphere for January, a winter month, and July, a summer month. The data are taken from the United States Hydrographic Office Pilot Charts.

The pressure distribution in the Southern Hemisphere is similar to that shown in Figures 1 and 2 except that the large oceanic anticyclones are not disposed symmetrically with those of the Northern Hemisphere; thus, for example, the anticyclone in the South Pacific is situated much nearer to the Continent of South America than the corresponding North Pacific anticyclone is to the Continent of North America.

Recalling the statement previously made as to the existence of a zone of low pressure in the equatorial regions that is bounded on both sides by belts of higher pressure, it will be readily understood that acting under the influence of gravity there will be a flow of air from the higher to the lower pressure; that is, from about latitude 30° N. and S. toward the Equator. The effect of the earth's rotation on its axis is to cause these winds to blow obliquely toward the Equator from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. These winds from their relative constancy in direction are known as trade winds.

The origin of the name, according to the Oxford English Dictionary, had nothing to do with "trade" in the sense of "'commerce' or passage for the purpose of trading, though the importance of those winds to navigation led eighteenth century etymologists and even navigators so to understand them."

The trades in their course Equatorward begin in the belts of high pressure, sometimes designated the horse latitudes, and end by giving way to the equatorial calms or doldrums. Further reference to the doldrums will be made later in this discussion.

The North Pacific semipermanent anticyclone.—The annual meandering of this formation is shown in Figure 3. Here again attention is directed to the injunction before expressed that the North Pacific anticyclone should not be thought of as a definite entity, but rather as the monthly average pressure over the ocean in certain geographical positions. In January the center of highest average pressure is found as indicated in the figure; its subsequent monthly mean positions are indicated, and a line

connecting them shows that the center makes a certain amount of westing and northing up to August when it is found in the position indicated; a movement back toward its winter position is then initiated, and the cycle of change begins anew in the succeeding year.

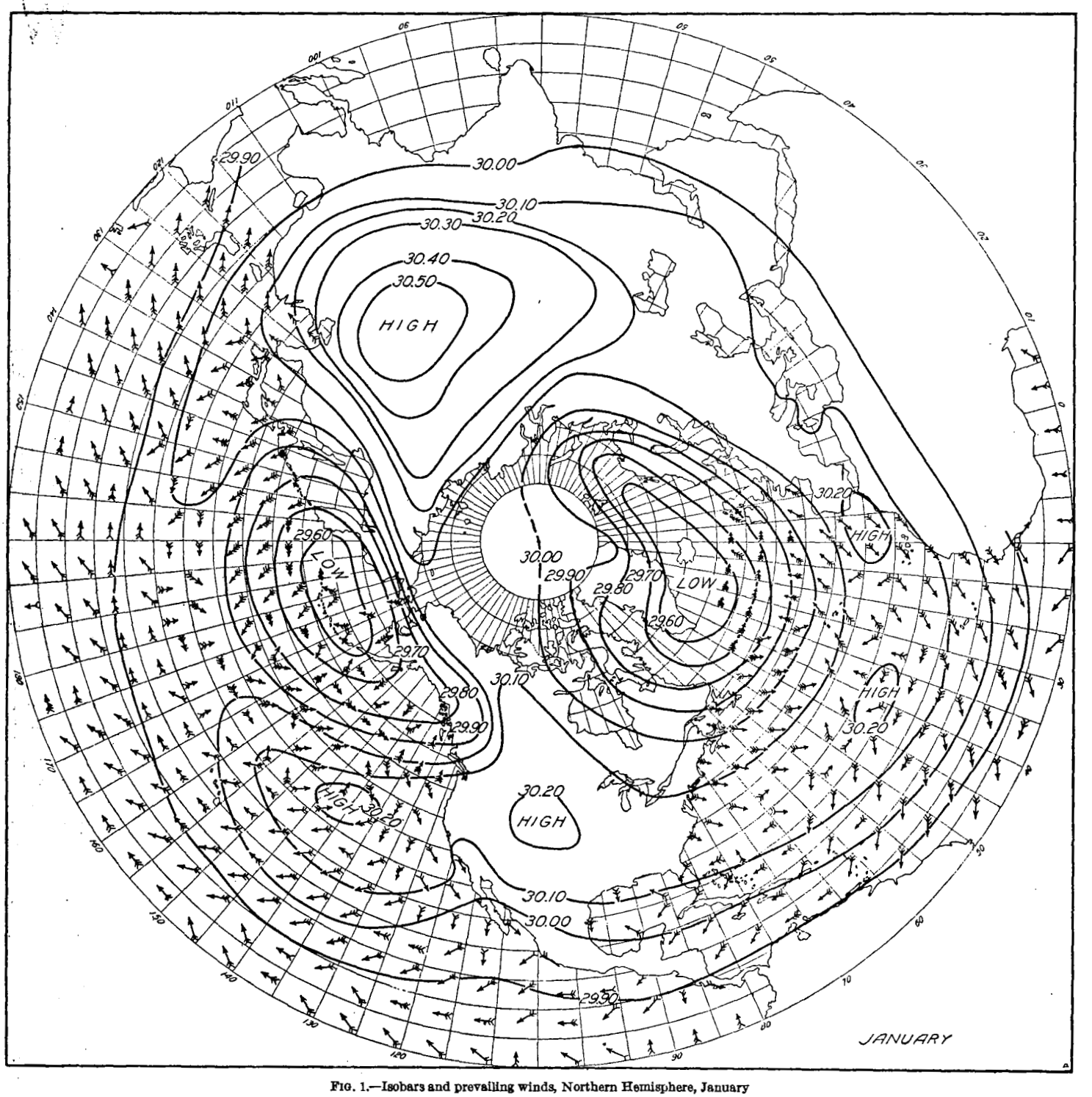

FIG. 1.—Isobars and prevailing winds, Northern Hemisphere, January

The movement of anticyclones over the Northeast Pacific is mostly in an easterly direction; it must happen then that when fresh bodies of relatively cool air are brought into the western or northern front of an existing anticyclone its wind circulation is increased thereby and there is a distinct response in the northeast trades which may persist for a day or so, after which they slacken until another impulse is received.

The semipermanent cyclone over the Aleutians attains its maximum geographic extent and intensity in January, as may be seen from Figure 1. It disappears in June and is not a disturbing factor between May and September.

Trade-wind boundaries.—The regions where the northeast trades prevail in the North Pacific may be traced in Figures 1 and 2, which show the prevailing wind direction for each 5° square for the months of January and July, respectively.

In winter the Siberian anticyclone is responsible for the northeast winds of the southeast coast of Asia.

The trades are weakest in September, when the northeast monsoon winds of Asia do not exist and the North Pacific anticyclone is rapidly diminishing in strength.

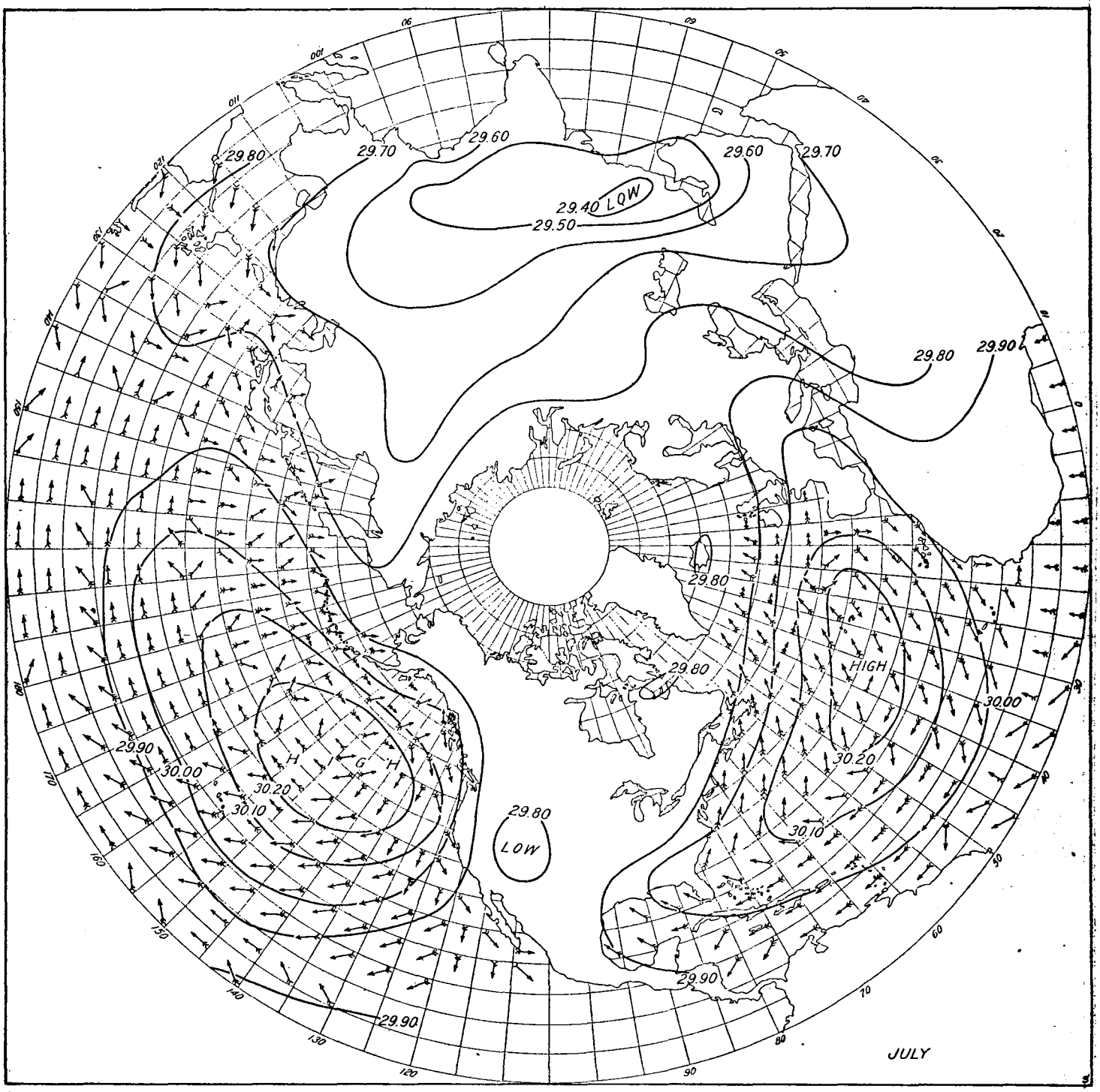

FIG. 2.—Isobars and prevailing winds, Northern Hemisphere, July

Recording trade-wind observations at sea.—Although weather observers on board ship record wind directions to 16 points of the compass, they are published on the North Pacific Pilot Charts on an 8-point scale; therefore a northeast wind on the Pilot Chart may be a wind coming anywhere from 22½° to 67½° on the compass. In other words, winds from the northeast, as recorded on the Pilot Charts, may have been recorded on the ship's log anywhere between NNE. and ENE., and the same discrepancy will apply to other directions.

On account of the wide range between the direction as recorded on the Pilot Charts and those which might have actually occurred, it will be difficult to determine the precise drift of the northeast trades. However, where an east wind prevails in one 5° square and a northeast in the next adjacent 5° square, it is reasonable to

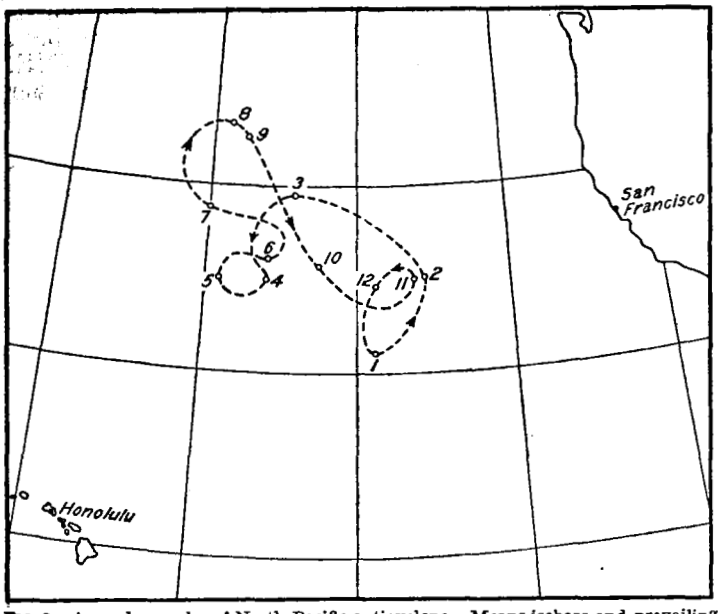

FIG. 3.—Annual meander of North Pacific anticyclone. Means isobars and prevailing winds over the Pacific

presume that the northeast wind had an easterly component and the east wind a northerly component and that the true direction of both winds was not far from east-northeast.

These facts should be considered when examining the wind directions both on the Pilot Charts and those of Figures 1 and 2, the latter having been taken directly from the former.

With these conditions in mind, and remembering that winds in the Northern Hemisphere blow spirally outward from anticyclones in a clockwise direction, it is probable that the directions of the trades at the extreme eastern side of the ocean have a marked northerly component. As one goes west within the trade-wind belt the winds veer more and more until they have a decidedly easterly component.

The southeast trades which blow spirally outward, but in a counterclockwise direction, from the semipermanent anticyclone in the eastern portion of the South Pacific follow the same system as the northeast trades. In the eastern part of that ocean they have a decided southerly component, but in going west they become more and more easterly, until at the northern edge of the southeast trades they merge with the corresponding winds at the

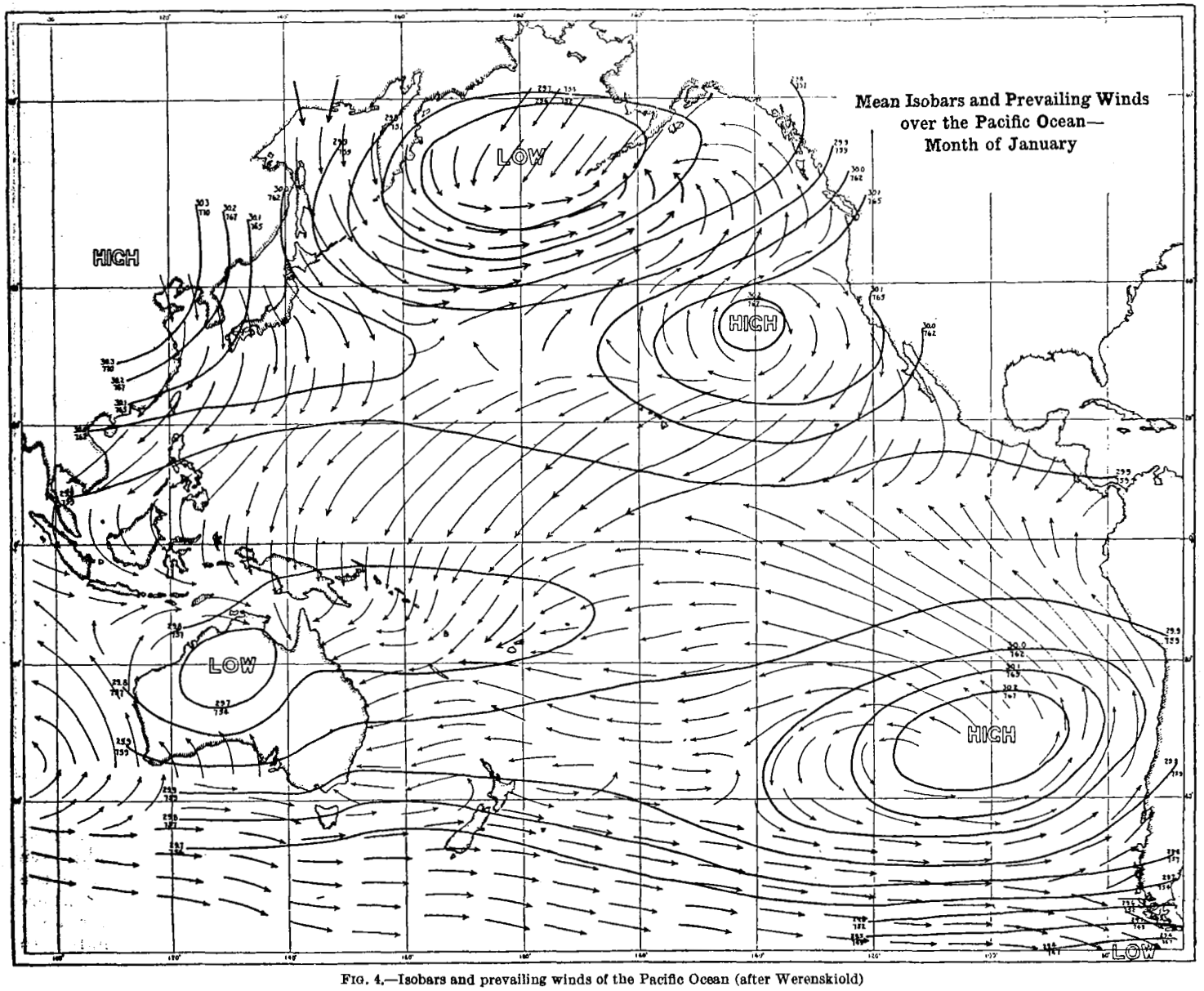

FIG. 4.—Isobars and prevailing winds of the Pacific Ocean (after Werenskiold)

southern edge of the northeast trades. Figures 4 and 5 illustrate these movements.[1]

In summer the northeast and southeast trades of the Pacific, as they approach the Equator, merge at about the 162d meridian of west longitude and in winter at about the 125th meridian, west. East of these longitudes there is a belt of calms, known as the doldrums, which varies in width from almost nothing to 20° or more of latitude. This belt of calms in the Pacific is V shaped with the widest portion near the coast. To the west of these longitudes, for 90° or more in winter and for 20° in summer, there is no belt of calms, but after passing to the west of about 140th meridian of east longitude in winter and the 180th meridian in summer another socalled belt of calms is encountered, which is also V shaped with its apex pointing east and with its base near the Asiatic coast.

One and probably the most important reason for the calm areas being of greater extent on both sides of the North Pacific in summer is due to the absence of the Siberian anticyclone and the cyclone over the Aleutians.

The absence of these formations, which is due entirely to seasonal conditions, causes a more uniform distribution of pressure both over land and water areas of northern latitudes. This in turn checks the general circulation of the atmosphere over the entire Northern Hemisphere, so that calms during summer months are not only most frequent in equatorial regions, but also in other parts of the North Pacific as well.

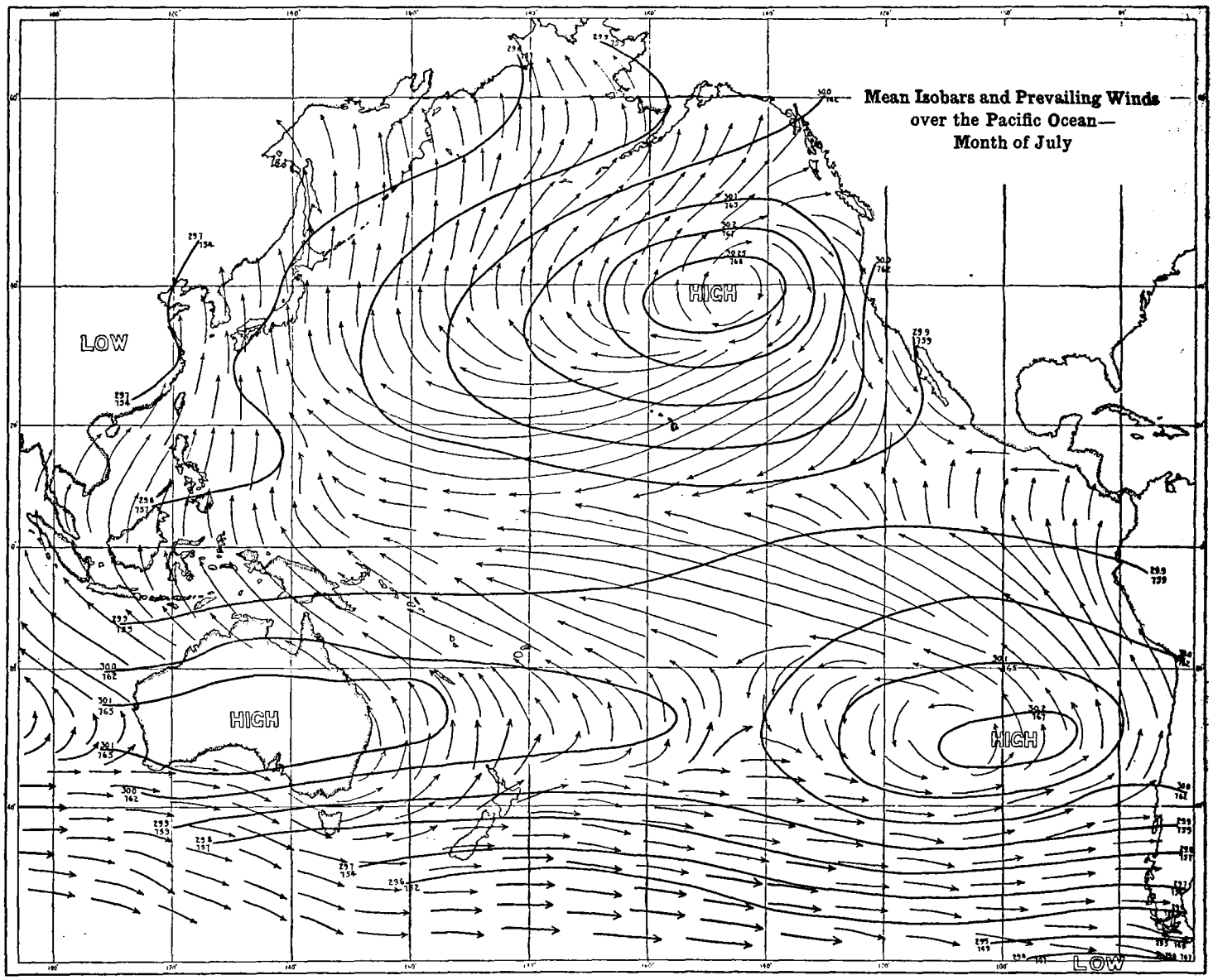

FIG. 5.—Mean isobars and prevailing winds over the Pacific Ocean, July (after Werenskiold)

Meteorological textbooks of North American origin describe a narrow belt of calms, called the doldrums, as existing between the northeast and the southeast trades and extending across both the Atlantic and the Pacific. So far as the Pacific is concerned there is no belt of calms extending across the entire breadth of that ocean. In fact only near the shore ends are there any considerable areas of calms, and these are due to weak pressure gradients.

Constancy of northeast trades.—It can be truly said that they blow continuously from somewhere between

[1] These charts have been taken from W. Werenskiold, "Mean monthly air transport over the North Pacific Ocean."

northeast and east within the central portions of their areas. Along their southern boundaries (in the Northern Hemisphere) there is some overlapping of the southeast trades, which for short periods occasionally prevail in places where the dominant wind is from the east or northeast. On their eastern boundary north winds are frequent, and the prevailing direction there is probably between north and northeast. On their western and northern boundaries winds other than northeast occur quite frequently, but their total percentage is much less than the percentage for northeasterly winds. Within the entire area the most infrequent winds are those between southwest and northwest, and their percentage is so small as to be scarcely worth mentioning, though it is well to know that they sometimes do occur along the northern and western boundaries of the Northeast trade belt.

HORSE LATITUDES

In the North Pacific there is no belt of calms in what are known as the horse latitudes.

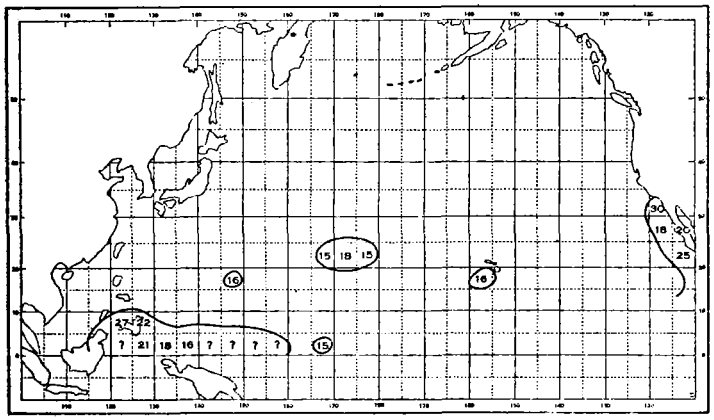

FIG. 6.—Areas of calm in the North Pacific, January

It is true that during summer months calms are more or less prevalent between the parallels of 30° and 40° north, especially in the middle part of the ocean, but at no time are they prevalent over its entire breadth in these or any other latitudes. During the winter months they are practically absent.

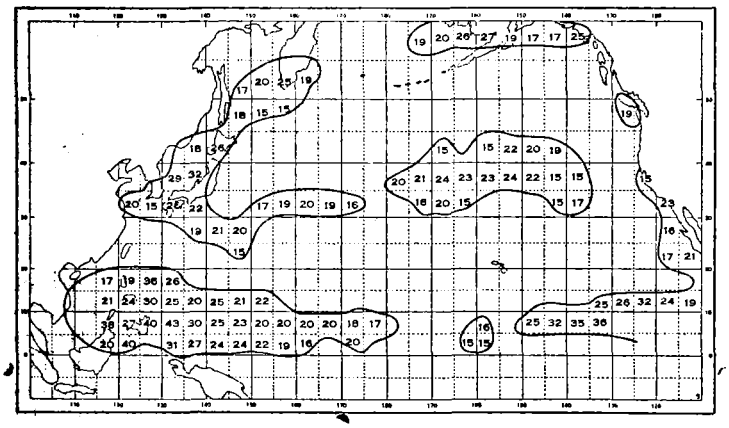

FIG. 7.—Areas of calm in North Pacific, July

In determining the prevalence of calms 15 per cent has been taken as a minimum number in a single month. All areas having 15 per cent or a greater number of calms have been classified as areas with frequent calms.

Figures 6 and 7 show these areas for the months of January and July.

The foregoing presents in outline the essential features of atmospheric pressure distribution in the Northern Hemisphere and the prevailing winds resulting therefrom. The latter are for the most part derived from ships' observations as compiled and published by the Weather Bureau and the Hydrographic Office of the Navy Department.

In the succeeding section the prevailing winds as recorded by instrumental means on certain islands of the Pacific will be presented and discussed.

CHAPTER II

SURFACE WIND DIRECTION

Honolulu.—Honolulu, N. Lat. 21° 7′; W. Long. 157° 54′, is situated on Oahu Island and on the leeward side of the Koolau range of mountains, which vary in altitude between 1,200 and 3,100 feet above mean sea level. This range is precipitous on its windward side and its trend is northwest/southeast, thus squarely facing the northeast trades of that part of the Pacific. These winds sweep through the passes of the range with high velocities, after which they spread fan shaped over the more level, leeward slopes upon which Honolulu is situated. (See figs. 8 and 9.)

As the trades cross the mountains before reaching the wind-recording instruments of the Honolulu Weather Bureau station, an allowance should be made for interference by land masses in both direction and velocity when considering their records.

A table has been formed which shows both the percentage of winds recorded from the eight principal points of the compass and the percentage of northeast and east winds for each month.

TABLE 1.—*Percentage of winds from the eight principal points of the compass and (below) percentage of northeast and east winds for each month of the year*

N.	NE.	E.		SE.		S.	SW.		W.	NW.	Calm
4.3	47.5	34.3		3.3		3.3	3.5		2.0	1.4	0.3
Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
63.0	65.9	71.0	82.0	83.5	92.4	95.5	94.3	90.8	85.7	83.0	73.6

This table shows that the northeast and east winds at Honolulu form about 80 per cent of the total winds and that the northeast trades are most frequently interrupted in winter and least in July and August, when they blow almost continuously.

The same data in another form are presented in Table 2, which shows the number of hours of northeast and east winds that prevailed at Honolulu for each year of the period 1905–1924, as taken from the automatic records of that station. The wind instruments were given a new exposure when the Weather Bureau office was removed from Young's Hotel to the Federal Building in May, 1922, and from that date onward the duration of the east wind, which had progressively increased at the old exposure as shown by five-year averages, increased at a much more rapid rate, as shown by Table 3.